

AM

PCT

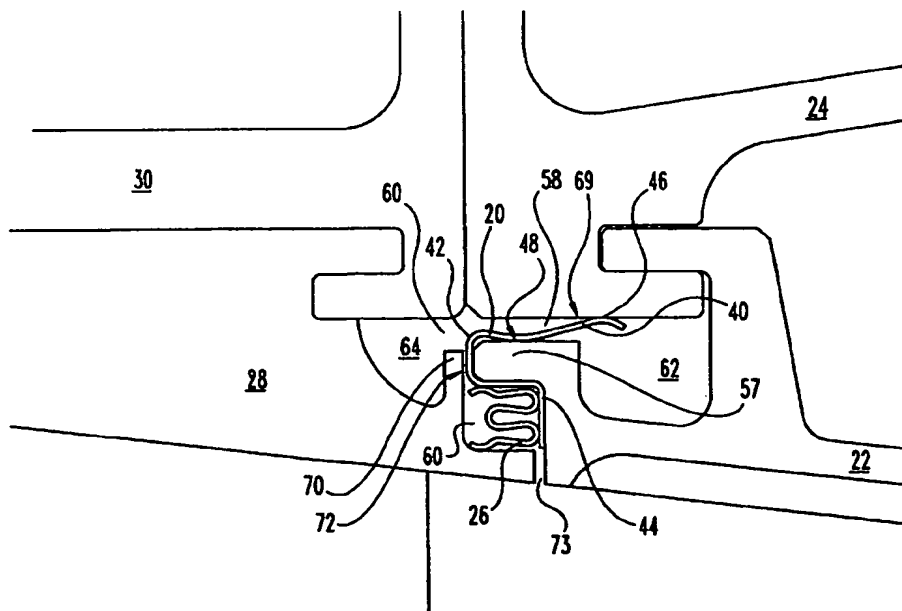
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : F16J 15/02, F01D 11/00		A1	(11) International Publication Number: WO 98/53228
			(43) International Publication Date: 26 November 1998 (26.11.98)
(21) International Application Number: PCT/US98/10369 (22) International Filing Date: 20 May 1998 (20.05.98) (30) Priority Data: 08/859,880 21 May 1997 (21.05.97) US (71) Applicant (for all designated States except US): ALLISON ADVANCED DEVELOPMENT COMPANY [US/US]; P.O. Box 7162, Indianapolis, IN 46206 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): RESS, Robert, Anthony, Jr. [US/US]; 218 West Admiral Way, Carmel, IN 46032 (US). DAVIS, Brian, Michael [US/US]; P.O. Box 62991, Cincinnati, OH 45262 (US). (74) Agents: ALLIE, John, H. et al.; Woodard, Emhardt, Naughton, Moriarty & McNett, Bank One Center/Tower, Suite 3700, 111 Monument Circle, Indianapolis, IN 46204 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: INTERSTAGE VANE SEAL APPARATUS



(57) Abstract

A sealing member (20) for sealing between static members, for example between static members (22, 28) of a gas turbine engine. The seal includes a first annular sealing member (20) which includes a first sealing portion (40) and a flange portion (42). The first sealing member seals a passageway (58, 60) between static members (22, 28). The flange portion (42) clamps around a flange (57) of a static member (22), and also seals a portion of circumferential gaps (74). The first sealing member (20) cooperates with a second sealing member (26) to seal a passageway (60). Attached to another leg (42c) of the flange portion (42) is a ring (44).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LJ	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

INTERSTAGE VANE SEAL APPARATUS

This invention was made under a United States Government contract and the United States Government has rights herein.

BACKGROUND OF THE INVENTION

5 The present invention relates generally to structures for sealing between static members within a gas turbine engine. More particularly, in one embodiment the present invention defines a vane interstage seal assembly for minimizing flow recirculating or leaking between vane stages
10 in a gas turbine engine. Although the present invention was developed for use in a gas turbine engine certain applications may be outside of this field.

Typically, the rotating components within a gas turbine engine include one or more rotors that rotate relative to a
15 static structure. Examples of various types of static members found in a gas turbine engine include vanes, stators, compressor cases, combustors, turbine cases, vane cases, fan cases, diffusers, combustor cases, and other components. Much of the engine's static structure is in
20 fluid communication with the working fluid, or flow path of the engine. As gas flows along the engine flow path, the pressure of the gas typically changes, increasing within the compressor and decreasing within the turbine, and creating a pressure differential that can lead to fluid leakage at
25 connecting points between members of the static structure.

Present gas turbine engine designs often use segmented static members. For example, static members such as vanes may be circumferentially segmented into arcuate pieces, such

-2-

as doublets or triplets, and axially limited to a single stage of expansion or compression. A vane assembly of this type would therefore have circumferential gaps or cavities between it's components and others of the same stage and
5 axial gaps or cavities between the vane assembly and vane assemblies of other stages. If these gaps, cavities, and passageways are not properly sealed, some amount of gas will recirculate off the flow path and around the static member. This recirculation decreases the efficiency of the
10 compressor or turbine, and lowers the overall efficiency of the engine.

Various apparatus have been proposed for providing seals within gas turbine engines. Examples of seals can be found in the following U.S. patents: No. 3,754,766 issued to
15 Asplund, No. 5,333,995 issued to Jacobs et al., No. 4,573,866 issued to Sandy, Jr. et al., 4,337,016 issued to Chaplin, No. 4,529,355 issued to Wilkinson, No. 5,188,506 issued to Creevy et al., No. 5,562,408 issued to Proctor et al., No. 3,518,020 issued to Lake, and No. 5,233,824 issued
20 to Clevenger.

Even with the variety of earlier designs, there remains a need for a vane interstage seal assembly in gas turbine engines. The present invention satisfies this need in a novel and unobvious way.

-3-

SUMMARY OF THE INVENTION

One form of the present invention contemplates an apparatus for sealing between static members of a gas turbine engine. The apparatus includes a first annular sealing member clamped to a second static member and contacting a first static member for reducing the passage of fluid between the members. The apparatus also includes a second sealing member contacting the first sealing member for reducing the passage of fluid along the second static member.

One object of the present invention is to provide an improved vane interstage seal for a gas turbine engine.

Other objects and advantages of the present invention will be apparent from the following description.

-4-

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cut-away view of a portion of a gas turbine engine having one embodiment of the present invention positioned therein.

5 FIG. 2 is a sectional view of the preferred embodiment of the present invention taken along line 2-2 of FIG. 1, with portions of the engine removed for clarity.

FIG. 3 is a cross-sectional view of FIG. 2 taken along line 3-3.

10 FIG. 4 is an enlarged view of FIG. 1.

FIG. 5 is a view FIG. 1 taken along line 5-5.

-5-

DESCRIPTION OF THE PREFERRED EMBODIMENT

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

FIG. 1 shows a portion of a gas turbine incorporating the preferred embodiment of the present invention. A second static member, compressor vane assembly 22, is shown installed by flanges received within pockets defined by a first static member, compressor case 24. A third static member, compressor vane 28, is shown installed by a flange to a fourth static member, bypass case 30. Bypass case 30 is fastened to compressor case 24. Although specific examples of static members are depicted and described, the present invention is also useful with other static members found in gas turbine engines, including stators, combustors, turbine cases, vane cases, fan cases, diffusers, combustor cases, and other nonrotating components.

Arrow 29 is parallel to the centerline of the engine axis, and also depicts the general direction of the primary gas or fluid flow path within the compressor. Air flowing in the primary flow path 29 through the compressor is largely contained between outer flow path 32 and inner flow path 34. A portion of the inner flow path between vanes 22 and 28 is not shown. In that portion, the inner flow path is defined by a plurality of compressor blades (not shown).

-6-

The outer tips of these compressor blades would pass within close proximity to abradable blade tip seals 36 and 38.

FIG. 1 shows first annular sealing member 20 as installed in the static structure. Second sealing member 26 is shown installed and sealing between portions of second static member, vane 22, and a third static member, vane 28.

FIG. 2 depicts sealing member 20 as seen along line 2-2 of FIG. 1, with sealing member 20 removed from the engine.

In the preferred embodiment, sealing member 20 has a generally circular, split construction, and formed from a single piece of sheet metal. Alternatively, sealing member 20 could be fabricated from different pieces that are welded, brazed, or bonded together. It can also be made from nonmetallic materials and various metals, provided the material has characteristics such as strength, coefficient of expansion, hardness and other properties suitable for the environment to which it is exposed. For example, sealing member 20 could be fabricated from a composite or stainless steel when used in a compressor assembly. As another example, sealing member 20 may be constructed from a nickel-based, iron-based, or cobalt-based material when used in a combustion or turbine section of the engine. Sealing member 20 is shown as a single piece, but could be made in two or more segments.

FIG. 3 is a cross sectional view of sealing member 20 of FIG. 2 taken along line 3-3. Sealing member 20 includes a first sealing portion 40 and a flange portion 42, the latter being generally U-shaped. Portion 40 is generally conically shaped, but is not limited to a conical shape. First sealing portion 40 is cantilevered from first leg 42a of flange portion 42. When installed between first static member 24 and second static member 22, seal 40 deforms elastically with sealing contact surface 46 being urged against surface 69 of member 24 (refer to FIG. 4). Surface

-7-

46 is formed on a radius of approximately 0.058 inches, although smaller and larger selections of radii work equally well. First sealing portion 40 is unitary or integral with flange portion 42, portions 40 and 42 joining in the vicinity of clamping contact surface 48. Surface 48 is formed on a radius of approximately 0.1 inches, although smaller or larger radii work equally well.

Flange portion 42 is in the approximate shape of the letter "U", incorporating opposing first and second legs 42a and 42c, respectively, joined by common side 42b. Ring 44 is attached to second leg 42c. Ring 44 and second leg 42c are joined at approximately the same angle as the corresponding surfaces of vane 22. In the preferred embodiment, second leg 42c and ring 44 are approximately perpendicular.

Common leg 42b is approximately perpendicular to side 42c. Side 42a is formed at an angle relative to side 42c, causing the open side of the U-shape to converge. Angle 50 is an acute angle in the preferred embodiment. As measured between sides 42c and 42a in the preferred embodiment is about 7.5°. As a result of this convergence, the top of the U-shape is more closed than the bottom, the difference in the width of the "U" providing spring characteristics for flange portion 42 as installed on flange 57. FIG. 4 is a close-up view of FIG. 1 in the vicinity of sealing member 20, showing sealing member 20 installed in an engine. Flange portion 42 clamps around flange 57 of second static member 22. Clamping contact surface 48 is expanded out, and the spring force of flange portion 42 couples sealing member 20 onto flange 57 by friction along the contact surfaces of sides 42a and 42c.

Installation of the sealing member 20 into the assembly consisting of first static member 24 and second static member 22 results in first sealing portion 40 becoming

-8-

somewhat flattened as sealing contact surface 46 comes into contact with surface 69 of first static member 24. First sealing portion 40 divides and seals various cavities, gaps, and passageways formed by the assembly of static members 22, 24, 28, and 30. The installation of vane 22 within compressor case 24 creates a first passageway 58. The assembly of vane 28 with bypass case 30 and vane 22 forms a second passageway 60. First sealing portion 40 seals a portion of first passageway 58 from second passageway 60, which passageways would otherwise be in fluid communication.

First passageway 58 contains gas 62 within it at a first pressure. The pressure of gas 62 is related to leakage of gas from the flow path of the engine, especially portions of the flow path downstream of first cavity 58. Second passageway 60 contains gas 64 at a second pressure lower than that of gas 62. Gas 62 is in fluid communication with surface 40a of first sealing portion 40, and gas 64 is in fluid communication with surface 40b. As a result of gas 62 being at a higher pressure than gas 64, there is a pressure imbalance across first sealing portion 40. This pressure imbalance creates a pressure load on seal 40 that tends to force sealing contact surface 46 against surface 69 of compressor case 24. This pressure load increases the sealing ability of sealing member 20, provided first sealing portion 40 is not so stiff as to resist deformation from this pressure load.

Second seal 26 is shown installed in the engine between third static member 28, leg 42c, and ring 44. Seal 26 may be of various configurations, and is shown as an "E" or "W" seal. Seal 26 is circular in nature, extending circumferentially around the engine. Vane 22 and vane 28 define an axial gap 73 between second passageway 60 and the primary flow path. Second seal 26 provides a seal between second passageway 60 and the primary flow path.

-9-

Third static member 28 also includes feature 70 which has obstructing surface 72 facing sealing member 20. Obstructing surface 72 limits movement of sealing member 20 if there is movement of sealing member 20 due to the
5 pressure imbalance, vibration, thermal cycling or other reasons. Surface 72 is shown spaced apart from sealing member 20.

FIG. 5 is a view of FIG. 1 taken along line 5-5. FIG. 5 shows a section of the front of compressor case 24 with two
10 second static members 22a and 22b attached. Vanes 22a and 22b define circumferential gap 74 between them. Sealing member 20 is shown installed. First sealing portion 40, leg 42b, and ring 44 are shown. Sealing member 20 seals a portion of circumferential gap 74. Each vane 22a and 22b
15 includes opposed, facing pockets 80 and 78, respectively, which have within them axial strip seal 76. Seal 76, located generally above abradable blade tip seal 38, seals high pressure air in cavity 62 that would otherwise leak between adjacent vanes. Seal 76 seals the balance of
20 circumferential gap 74.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred
25 embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

-10-

WHAT IS CLAIMED IS:

1. An apparatus for sealing between a first static member and one or more second static members within a gas turbine engine, comprising:

- 5 a first annular sealing member clamped to the second static member and contacting the first static member for reducing the passage of fluid between the members; and
a second sealing member contacting said first sealing member for reducing the passage of fluid along the second
10 static member.

2. The apparatus of claim 1, further comprising a third static member, wherein said second sealing member reduces the passage of fluid between the second static member and the third static member.

- 15 3. The apparatus of claim 2, wherein the third static member comprises a compressor vane.

4. The apparatus of claim 1, wherein said first sealing member having a substantially conically shaped portion.

- 20 5. The apparatus of claim 1, wherein the second static member comprises a compressor vane having a flange thereon, and wherein said first sealing member clamping the flange.

6. The apparatus of claim 5, wherein said first sealing member having an approximate U shaped portion for
25 clamping said flange.

7. The apparatus of claim 1, further comprising a third static member, the third static member having an obstructing portion for limiting the movement of said first sealing member.

-11-

8. The apparatus of claim 1, wherein said second sealing member is an E seal or a W seal.

9. The apparatus of claim 1 which further includes a plurality of second static members that are adjacent one another and have a circumferential gap therebetween, and wherein said first sealing member sealing a portion of said circumferential gap.

10. An apparatus for sealing between a first static member and a second static member within a gas turbine engine having a primary flow path, comprising:

a first annular seal having a first sealing portion and a flange portion;

the second static member and the first static member being spaced so as to define a passageway therebetween;

wherein said first sealing portion extends across said passageway for reducing the passage of fluid through said passageway, and said flange portion wrapping around at least a portion of one of the first or second static members so as to hold said first annular seal in place.

11. The apparatus of claim 10, further comprising a second seal contacting said first annular seal.

12. The apparatus of claim 11, further comprising a third static member, wherein the second static member and the third static member define a second passageway therebetween, and wherein said second seal sealing the second passageway from the primary flow path.

13. The apparatus of claim 10, wherein the second static member comprises two adjacent vane segments having a circumferential gap therebetween, and said flange portion seals a portion of the circumferential gap.

-12-

14. The apparatus of claim 10, wherein the second static member is a compressor vane.

15. A sealing apparatus positioned within a gas turbine engine having a first, second and third static member

5 proximate to a primary flow path, comprising:

a fluid passageway defined by the first, second and third static members that is disposed in fluid communication with the primary flow path; and

10 a first annular sealing member positioned within said passageway and contacting the first and second static members for minimizing the flow of fluid out of said passageway.

16. The apparatus of claim 15, further comprising a second sealing member for minimizing the flow of fluid out
15 of said passageway.

17. The apparatus of claim 15, wherein said first annular sealing member is pressure loaded toward the first static member for further reducing the flow of fluid from said passageway.

20 18. The apparatus of claim 15, wherein the second static member is a compressor vane.

19. An apparatus for sealing between a first static member and a second static member within a gas turbine engine, comprising:

25 a passageway between the first static member and the second static member; and

an annular cantilevered sealing member extending across said passageway for reducing the passage of fluid therethrough, said sealing member having a first portion

-13-

coupled to the second static member and a second portion contacting the first static member.

20. The apparatus of claim 19, wherein said first portion and said second portion are integral.

5 21. The apparatus of claim 20, wherein said first portion has a first leg and an opposite second leg, and wherein said first leg and said second leg are not parallel.

22. The apparatus of claim 21, wherein said first leg and said second leg converge at an acute angle.

10 23. The apparatus of claim 22, wherein said acute angle is about seven and one half degrees.

24. The apparatus of claim 22, further comprising a ring coupled to the second leg.

15 25. The apparatus of claim 24, wherein said ring is oriented approximately perpendicularly to said second leg.

26. The apparatus of claim 24, wherein said first portion, said second portion, and said ring are formed as a single piece.

20 27. The apparatus of claim 26, wherein the piece is an iron-based, nickel-based, or cobalt-based metal.

28. The apparatus of claim 26, wherein said sealing member is segmented.

25 29. A combination for sealing between a first static member, a second static member, and a third static member within a gas turbine engine, comprising:

-14-

a first annular means for sealing clamped to the second static member and contacting the first static member for reducing the passage of fluid between the members; and

5 a second annular means for sealing cooperating with said first sealing means for reducing the passage of fluid along the second static member.

30. The combination of claim 29, wherein said second sealing means reduces the passage of fluid between the second static member and the third static member.

10 31. The combination of claim 30, wherein the third static member comprises a compressor vane.

32. The combination of claim 29, wherein the second static member comprises a compressor vane.

15 33. The combination of claim 29, wherein the first static member comprises a compressor case.

34. The combination of claim 29, wherein the third static member has an obstructing surface, the obstructing surface limiting the movement of said first sealing means.

20 35. The combination of claim 29, wherein two second static members define a circumferential gap therebetween, and said first sealing means provides a seal over a portion of the circumferential gap.

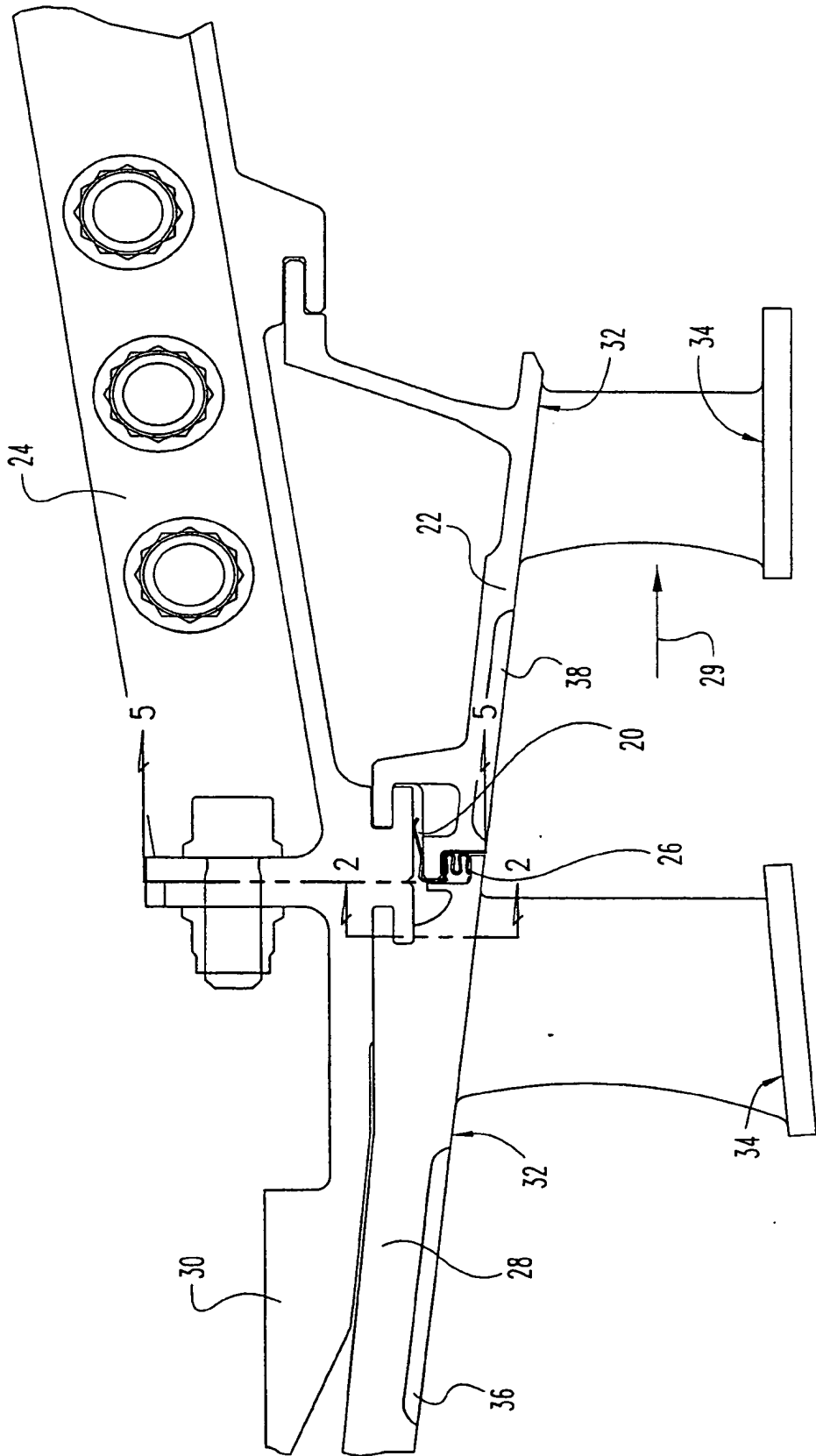


Fig. 1

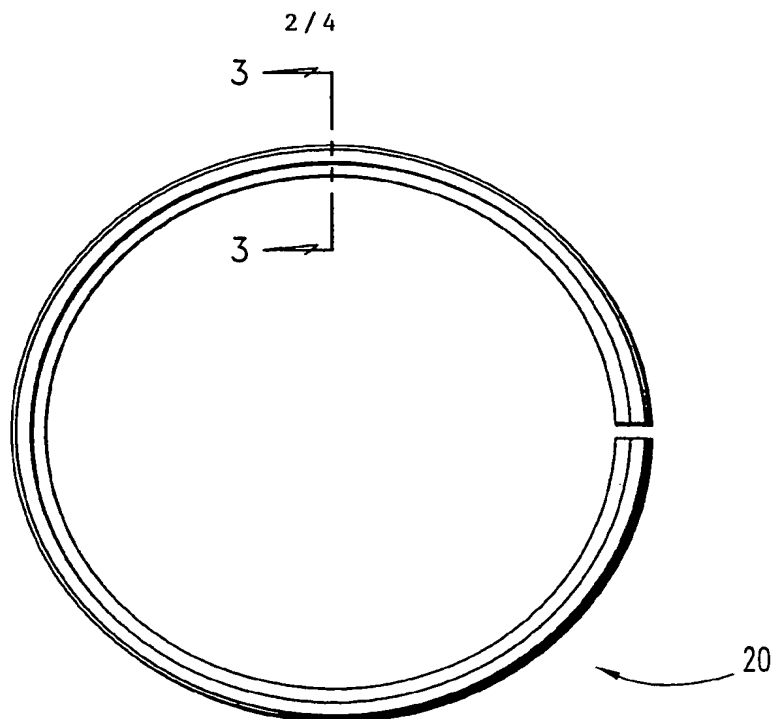


Fig. 2

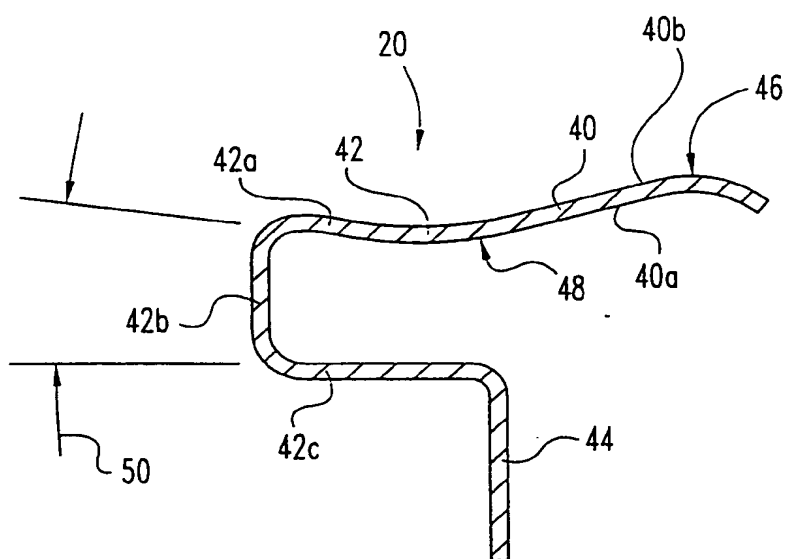


Fig. 3

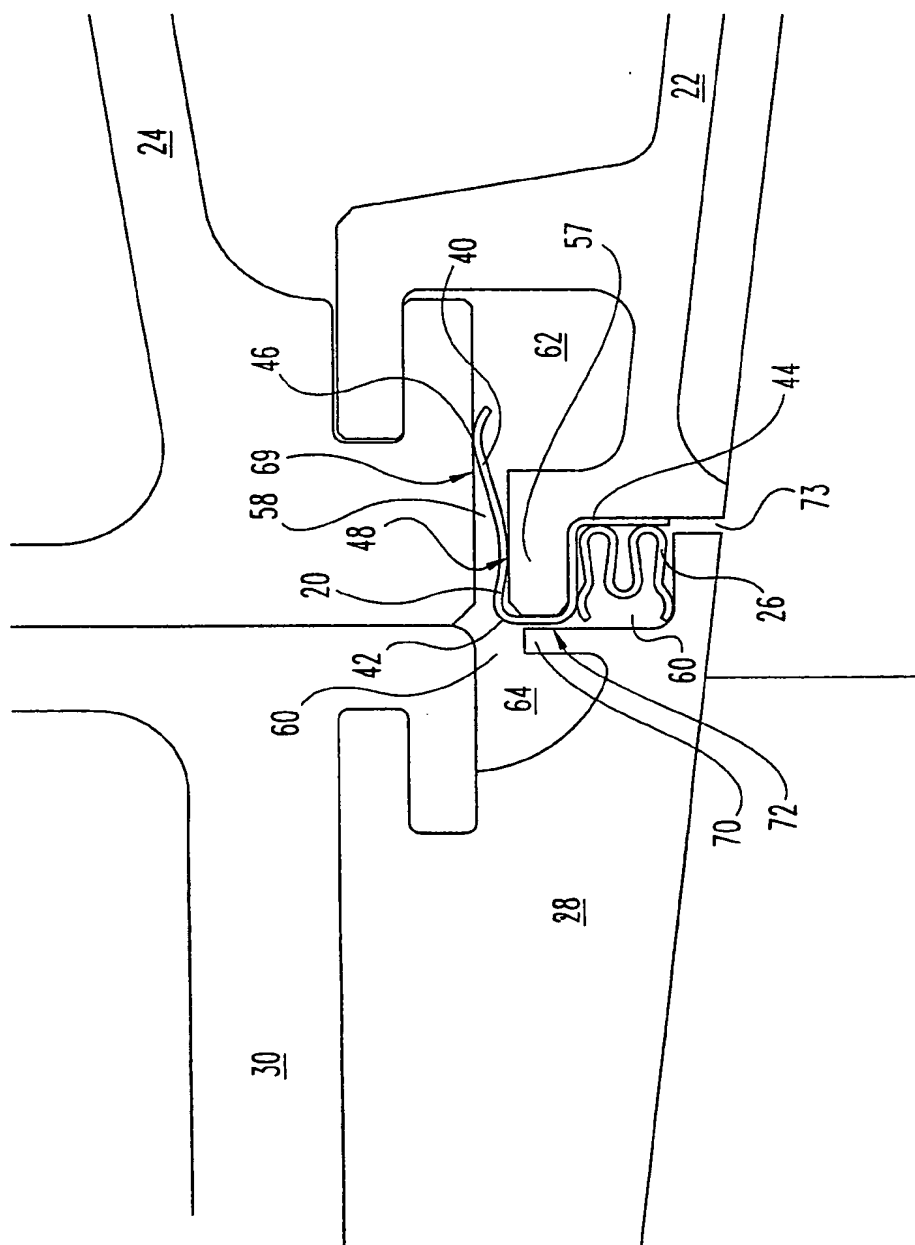


Fig. 4

4 / 4

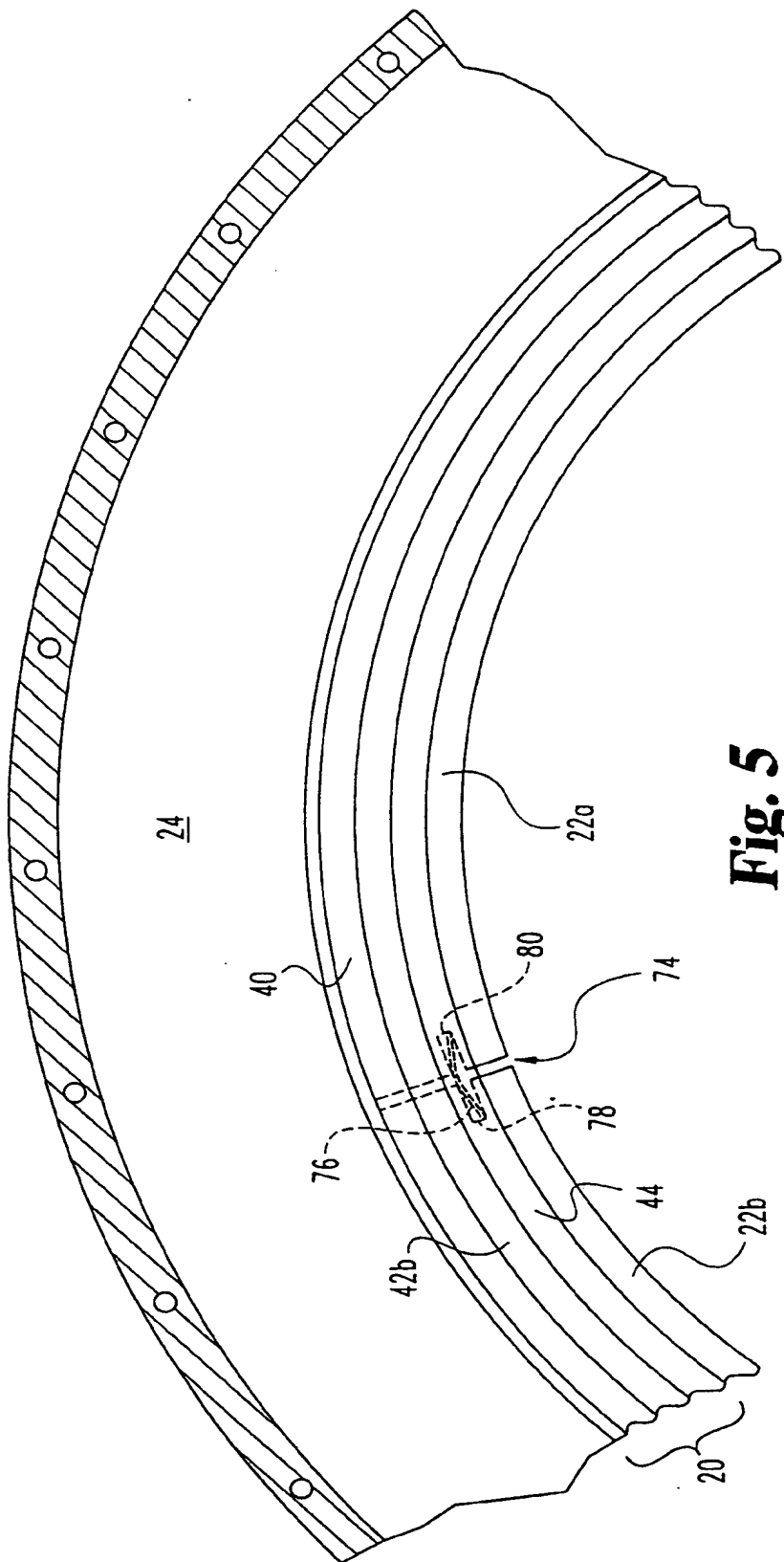


Fig. 5

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/US98/10369

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F16J 15/02; F01D 11/00

US CL : 277/637

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 277/628, 637, 644; 415/170.1, 173.1, 173.3, 174.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,562,408 A (PROCTOR ET AL) 08 October 1996 (08/10/96), see figure 2 and the W-shaped seal depicted therein.	15-22
X	US 5,333,995 A (JACOBS ET AL) 02 August 1994 (02/08/94), see figures 2 and 4 and the descriptions thereof.	1-3, 10-12, 14-20 and 29-31
X	US 5,192,185 A (LEONARD) 09 March 1993 (09/03/93), see entire document.	1, 7, 10, 11, 14-18, 29 and 34
X	US 5,188,507 A (SWEENEY) 23 February 1993 (23/02/93), see entire document.	10, 14, 15 and 17-21
X	US 5,145,316 A (BIRCH) 08 September 1992 (08/09/92), see entire document.	1-8, 15-20 and 29-35

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

30 SEPTEMBER 1998

Date of mailing of the international search report

26 OCT 1998

 Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

 Authorized officer
JOHN L. BERES

Telephone No. (703) 308-2168

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/10369

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,255,890 A (MORRILL) 26 October 1993 (26/10/93), see figure 5 and the description thereof.	1, 4 and 29
X,P	US 5,678,827 A (BURIAN ET AL) 21 October 1997 (21/10/97), see entire document.	10
X	US 5,007,202 A (GUILLON) 16 April 1991 (16/04/91), see entire document.	19-22